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TEST AND EVALUATION OF AN EXPERIMENTAL FEASIBILITY PROTOTYPE PASSIVE SEAT MOUNTED LIMB RESTRAINT SYSTEM

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An experimental feasibility prototype of passive seat mounted limb restraint system was tested under various conditions both statically and dynamically on the NAVAIRDEVCEN Ejection Tower and the Dayton T. Brown windblast facility. The Ejection Tower tests resulted in successful and repeatable entrapment of the arm and legs, and good tensioning of the restraint lines through one-way snubbers. The windblast test series also resulted in successful entrapment of the limbs at various pitch and yaw angles up to 600 knots. The results of this T&E study clearly showed the feasibility of the system to provide the over

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20 necessary protection to the crewmember during the simulated operation environments, and also to meet the passive requirements which results in no additional encumbrances on the crewmember.

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INTRODUCTION

The objective of this test and evaluation program was to determine the feasibility of a passive, seat mounted limb retention prototype restraint and protection system. This system was designed to provide crewmen with a system which would reduce their physiological exposure to aerodynamic and deceleration forces during high speed ejection up to 600 knots.

This prototype system was developed under contract No. N62269-77-C-0251 by Stencel Aero Engineering Corp. and was delivered in August 1978. The test evaluation program was conducted in three phases: Phase I - Static Evaluation; Phase II - Ejection Tower Evaluation; and Phase III - Windblast Test Evaluation.

Phases I and II were conducted with the restraint system installed on the Navy's Maximum Performance Escape System (MPES) ejection seat, for which it was originally configured. For the windblast testing phase, the system was installed on an Escapac type ejection seat and required minimal modification to the original configuration.

This program was sponsored by the Naval Air Systems Command, code Air-340-B under an exploratory development phase study whose objective is to develop and evaluate the feasibility and practicality of various approaches to satisfy new requirements or improve current deficiencies.

A complete description of this prototype limb restraint system is provided in NADC report No. NADC-79201-60 of May 1979.

TEST PROGRAM OBJECTIVES

STATIC EVALUATION - PHASE I

To demonstrate the effectiveness of the system to deploy and entrap the limbs.

To demonstrate that the system is compatible with the seat and crew mounted equipment, injury potential assessment, ingress and capability and crew accommodation.

To demonstrate the effectiveness of seat-man separation capability in a walk-through simulation.

EJECTION TOWER EVALUATION - PHASE II

To demonstrate the effectiveness of the system to entrap the legs and satisfactorily cinch up the restraint straps during the catapult phase of escape. (See table I, page 56).

WINDBLAST TESTING - PHASE III

To demonstrate the effectiveness of the system to restrain and protect the limbs at various pitch and yaw attitudes during simulated ejection environments between 400 - 600 keas. (See table II, page 56).

TEST HARDWARE AND MATERIAL

Two complete sets of inflatable bladders and connecting hardware

One rechargeable air cylinder

One complete limb restraint unit consisting of netting, restraint lines and snubbers

Twelve pairs of rip-stitch energy attenuation (E/A) tensioning lanyards

One seat back pad with bladder stowage pockets

One seat cushion with bladder stowage pockets

One set of interconnecting tubing and attachment fittings

One set of repackaging instructions.

TEST DESCRIPTION

PHASE I - STATIC DEPLOYMENT

These tests consisted of mainly functional deployment tests utilizing subjects approximating as closely as possible the 5th, 50th and 95th percentile population to determine if the strap and bladder configuration was adequate for effective entrapment without readjustments for size variations.

Each subject was tested in two seated positions:

1. Normal ejection position with hands on 'D' ring.

2. Hands on knees with the subject sitting slightly forward.

These tests also examined the seat-man release condition to determine if any potential hang-ups or equipment interference were possible.

The position of the deployable leg lines and bladders were initially adjusted to a position which was felt to be adequate for all size subjects.

The 5th percentile subject was tested first. The subject seated and positioned himself and attached his lap belt and shoulder harness straps in the normal manner. The system was deployed from the stowed condition by actuating a compressed air bottle via a solenoid. Upon full deployment, the tensioning lines were manually pulled to simulate the effect of seat motion pulling them as it moves up the rails. This action pulled the leg restraint lines from the velcro tape fasteners holding them to the inflated deployment bladders and entraped the legs against the seat side panels. Figure 1 shows how the restraint line is routed around the leg and through the snubber following full deployment and retraction. Visual examination showed excellent entrapment, with the leg lines across the middle of the anterior thigh holding the leg down onto the seat pan and across the middle of the anterior lower leg holding it tightly back against the seat front panel and against the seat side panel.

Although complete entrapment was obtained, complete cinching was not obtained because it was impossible to manually pull with a 400-lb load on each restraint line as would be obtained via the rip-stitch E/A tensioning lanyards during ejection.

FIGURE 1 - Restraint System - Deployed Condition

The restraint system was repackaged and deployed numerous times with the same subject in slightly different positions. Each time, the system operated with repeatable success. Following each deployment and tensioning sequence, the system was released and the subject stood up and egressed the seat with no difficulty.

The subject representing the 50th percentile in stature also experienced the same repeatable successful entrapment/egress cycle with no problems.

The restraint lines appeared optimally placed for proper leg retention, and the nets entrapped the arms with the elbow in the mid-length of the net. The subject was able to egress the seat with no hesitation. The only gear not worn by the subjects was the survival vest with the life preserver assembly (LPA) attached.

The subject representing the 95th percentile in stature was evaluated in same manner as the previous subjects. In these series, it was evident that the leg straps and arm nets did not capture the subjects limbs at the same locations, although satisfactory entrapment did occur.

The leg straps captured the legs approximately 2 inches below the knee, and the subjects elbows were positioned towards the upper end of the net. This condition was carefully observed during the ejection tower and windblast testing to determine if any adverse effects occured. The seat/man separation trials successfully demonstrated clean egress under the existing controlled conditions.

On the basis of the static evaluation, the installation position of the limb retention was considered satisfactory and the seat and restraint system was prepared for installation on the NADC Ejection Tower for further evaluation.

PHASE II - EJECTION TOWER TESTING

The objective of these tests was to demonstrate the suitability of the system design and installation configuration to entrap and restrain the legs during a simulated ejection under conditions of actual onset rate and peak G's associated with standard ejection forces normally encountered with operational seats.

The performance requirement was that straps entrap the legs of both the 5th and 95th percentile dummy and be fully retracted and restrained after the straps have been pulled off the deployment bags via the rip-stitch E/A lanyards which are attached to the floor through a safety shear pin. The E/A lanyard was connected through a strain gage to record the separation loads.

The dummies were seated in the normal full back position with the inertia reel locked and the hands approximating the 'D' ring position.

The deployment phase of the system operation was preinflated since it had already been evaluated during the static testing, and more importantly, because it eliminated any concern regarding sequencing requirements which would have unnecessarily complicated the test procedure. Finally, because it also eliminated the need to continuously repack the restraint system which would have

caused additional delays in the test cycle. The leg restraint straps were, however, still attached via the velcro tape to the leg deployment bladders (figure 2), and the entrapment and cinching function was initiated by the motion of the ejection seat up the rails.

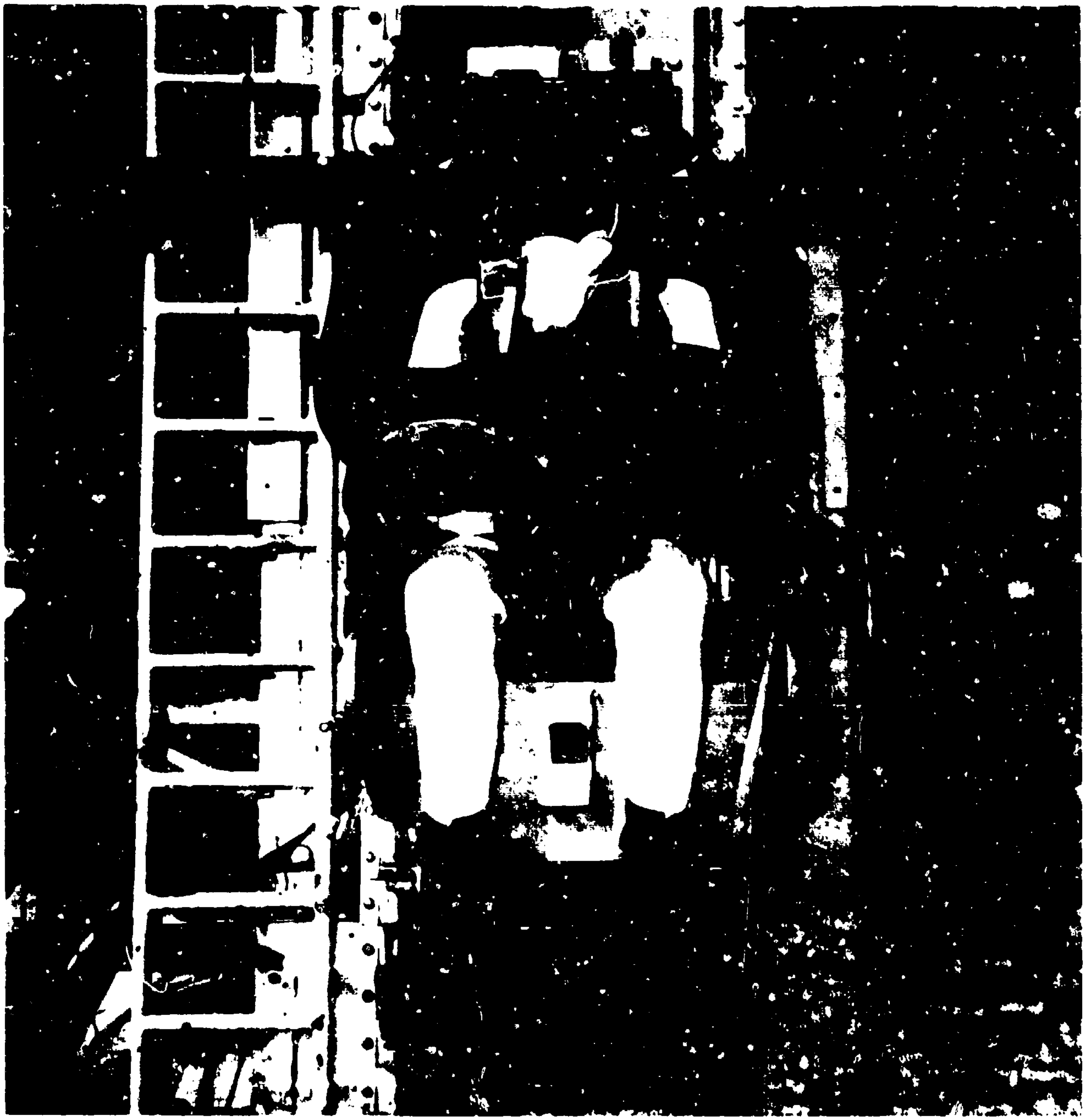

FIGURE 2 - Ejection Tower PreTest Position

In order to predeploy the inflatable bladders and keep them inflated during the ejection, it was necessary to modify the system slightly. Since each of the bladders were designed with blowout ports, each bag had to be temporarily plugged to prevent the air from escaping, thereby failing to position the restraint lines in the proper position. Also, since the seams on the bladders were not air-tight, an air bottle was installed under the seat which was plumbed to the inflation lines via a metering valve to give a constant flow of air to compensate for the leakage and maintain a constant pressure in the bladders.

INSTRUMENTATION

Only four channels of information were necessary and consisted of:

Seat Acceleration

Catapult Pressure

Left E/A Strap Load

Right E/A Strap Load

Test Results

The original intention was to conduct only four ejection firings to evaluate the leg entrapment and cinching function. Due to a repeated failure of the one way snubber mechanism, it was necessary to fire 4 preliminary tests with the 5th percentile dummy set-up to obtain a satisfactory redesign and positioning of the snubber on the seat. Although each of the first four tests resulted in successful entrapment of the legs during the initial phase of the ejection, as required, the failure of the snubber mechanism resulted in inappropriate tensioning of the restraint lines and caused a no-test condition since the overall restraint line performance could not be evaluated. Figure 3 shows a trace typical of the first four tests.

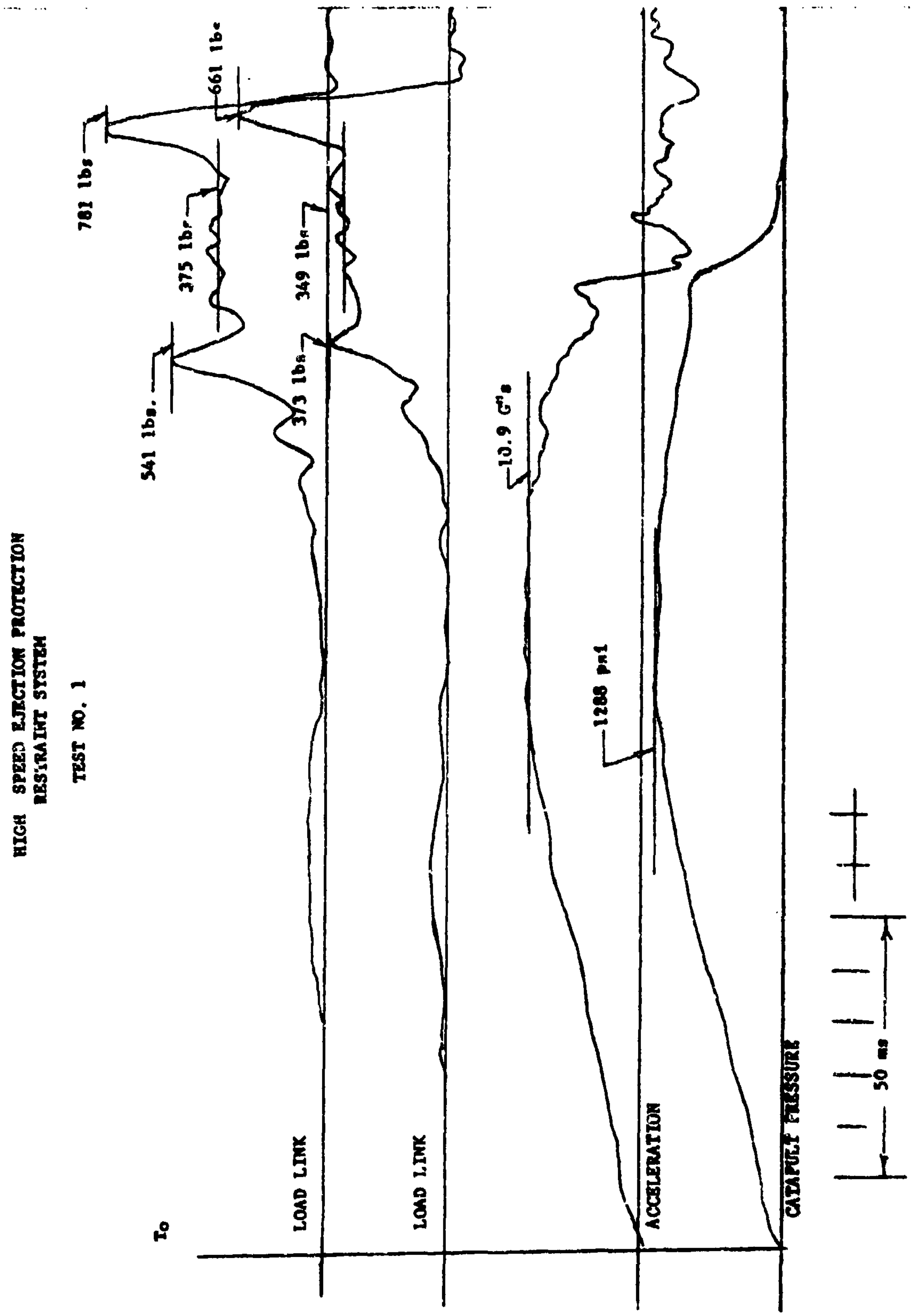

FIGURE 3 - Oscillograph Record - Ejection Test No. 1

For test number 5, a new snubber bracket was fabricated along with a roller follower to guide the straps around the bottom front edge of the seat bucket. The snubber mechanism was relocated approximately 7 inches back from the front edge (figure 4).

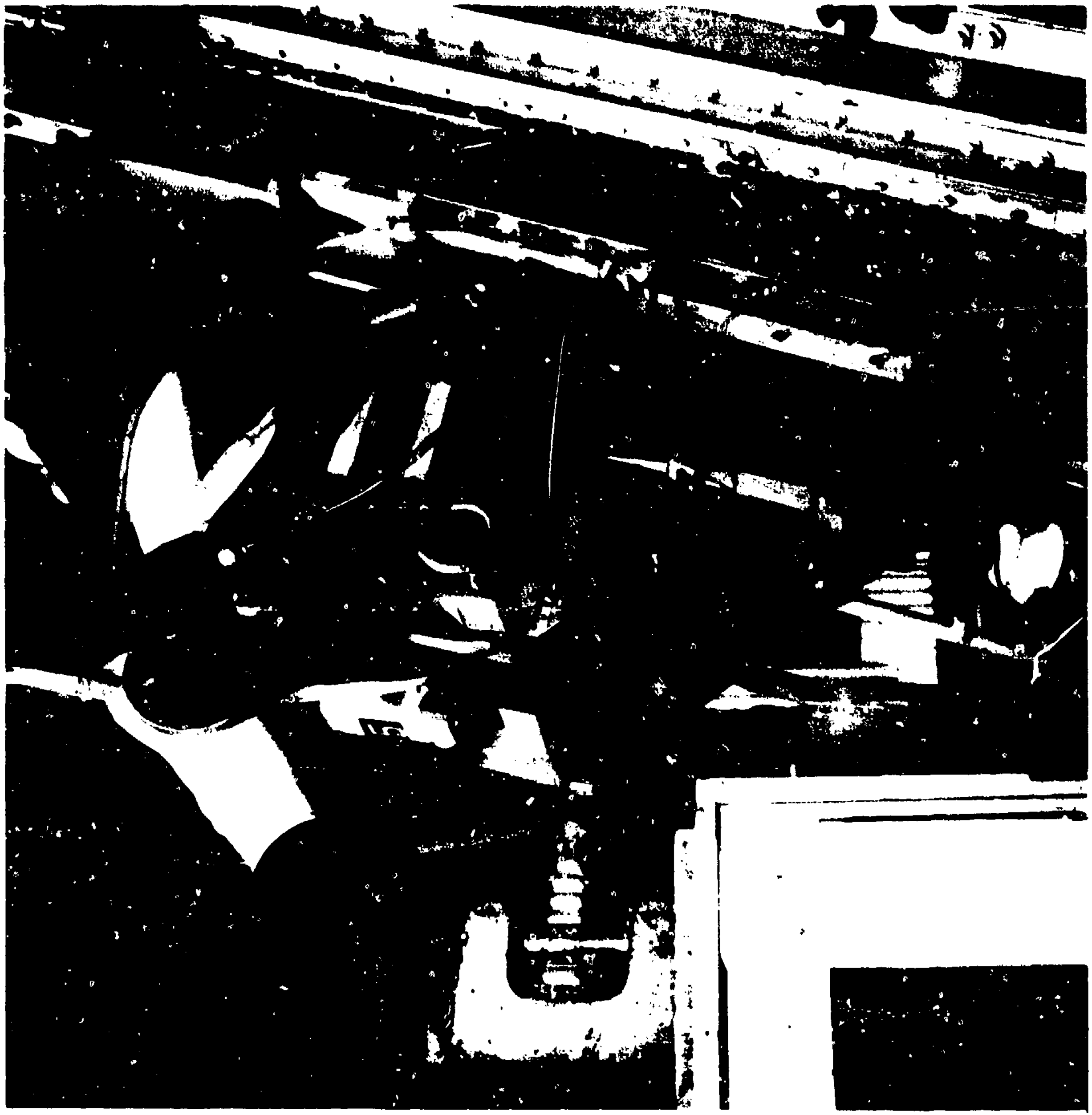

FIGURE 4 - Snubber Mechanism Redesign

An additional section of restraint strap was sewn to the existing strap line to compensate for relocating the snubber. Unfortunately this new stitching separated on one side and satisfactory tensioning again did not occur, although the leg entrapment function worked perfectly for the 5th consecutive time. The new snubber design worked perfectly.

Test number 6 was the last one conducted with the 5th percentile dummy (figure 5). This test, again, resulted in successful entrapment of the legs, showing excellent repeatibility.

FIGURE 5 - Ejection Test No. 6 - Test - Set-Up

The leg lines were completely retracted and locked through the snubbers. The dummy's legs were tightly restrained against the seat and the system also provided excellent restraint for the arms (figures 6 and 7). A review of the oscillograph record (figure 8) revealed an undesirable high spike at the end of E/A webbing separation of approximately 898 lb. This was considered excessive over the nominal tearing load of 400 pounds ± 10%. Since this was the first test in which the E/A webbing fully separated, there was no prior indication of excessive E/A loading. An examination of the E/A webbing lanyard revealed four rows of stitching at the separation end which were sewn across, or normal to the direction of the rip-stitch pattern. It was determined that this was the cause of the spike loads and also was responsible for the problem with the snubber. These four rows of stitching were removed from the remaining sets of E/A straps which were to be used for the balance of testing.

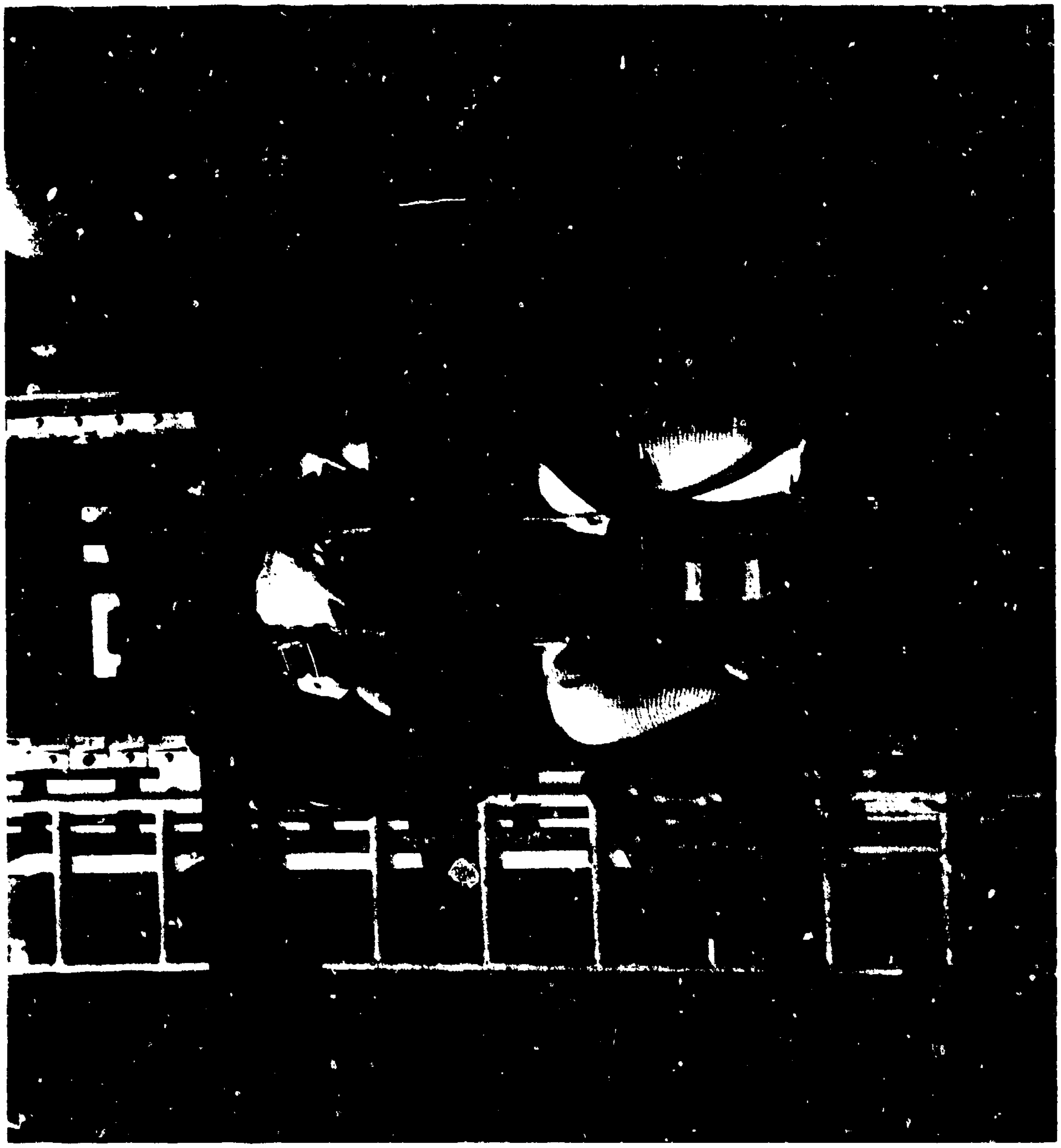

FIGURE 6 - Post Test Condition - Front View

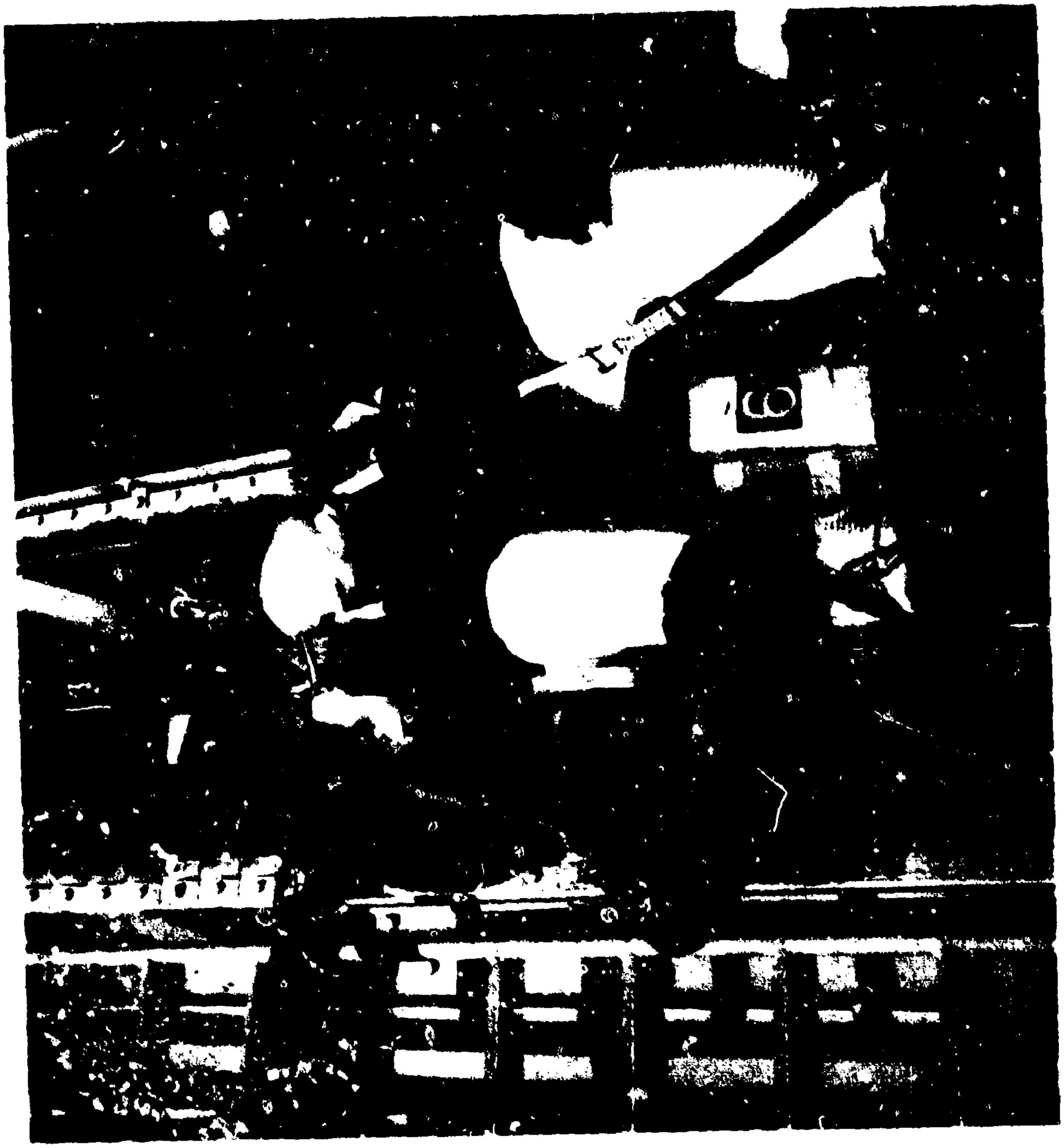

FIGURE 7 - Post Test Condition - 3/4 View

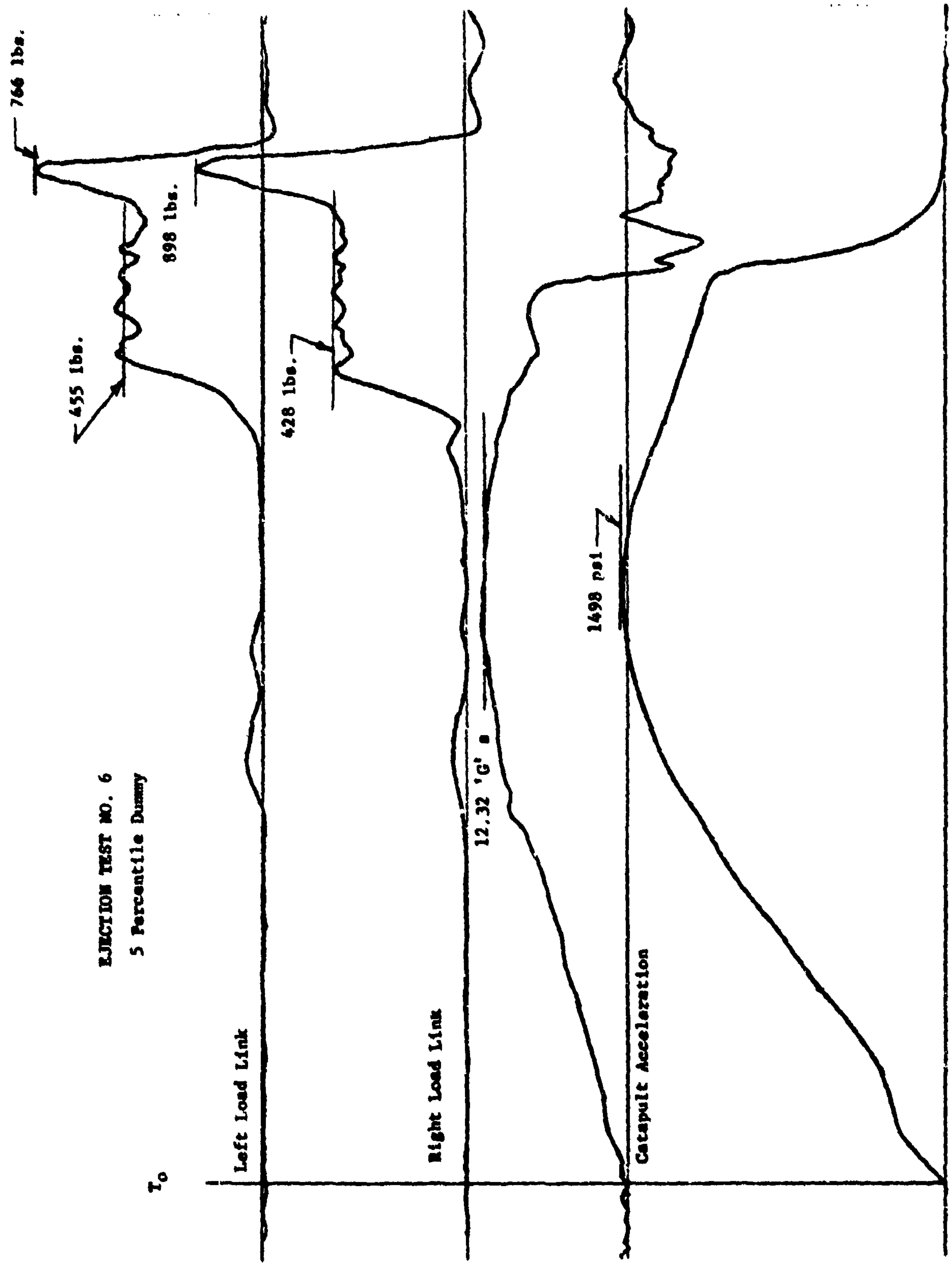

FIGURE 8 - Oscillograph Record - Test No. 6

Upon completion of test No. 6 it was determined that sufficient data had been obtained regarding deployment of the straps around the limbs of the 5th percentile dummy. Any additional information of the tensioning function could be obtained from tests 7 through 9.

For test No. 7, the 95th percentile dummy was also set-up in the predeployed mode to assure a fair demonstration that the leg restraint configuration was capable of consistantly entraping the legs during the ejection phase. The set-up for test No. 7 is shown in figures 9 and 10.

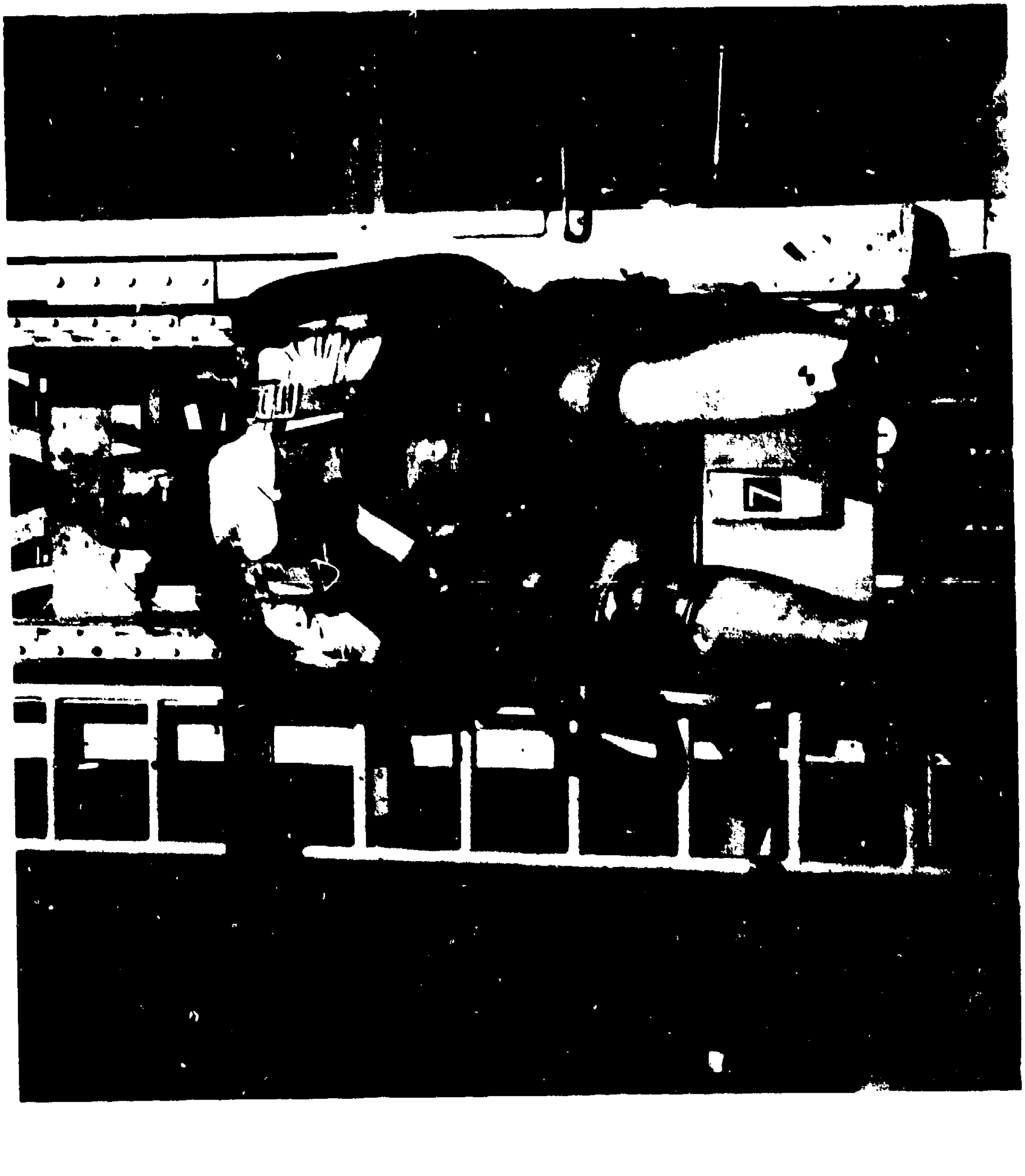

FIGURE 9 - Ejection Test No. 7 Set-Up - Front View

FIGURE 10 - Ejection Test No. 7 - Set-Up - Side View

This test resulted in successful entrapment of the legs and full tensioning of the restraint lines through the snubbers. Although the restraint straps captured the legs in a position closer to the knee, as was evidenced during the static evaluation, the degree of restraint was equally as effective. Post test examination found it impossible to move the legs in their restrained position. Except for an initial break-out load, which is characteristic, the instrumentation record (figure 11) shows a fairly steady E/A ripping load between 430 lb. for the left strap and 443 lb. for the right strap. The oscillograph record shows the absence of the excessive spike loads at webbing separation, which were experienced during all the previous tests where complete separation of the webbing occured. This was a significant improvement in system performance, and these modified straps were used for the balance of testing.

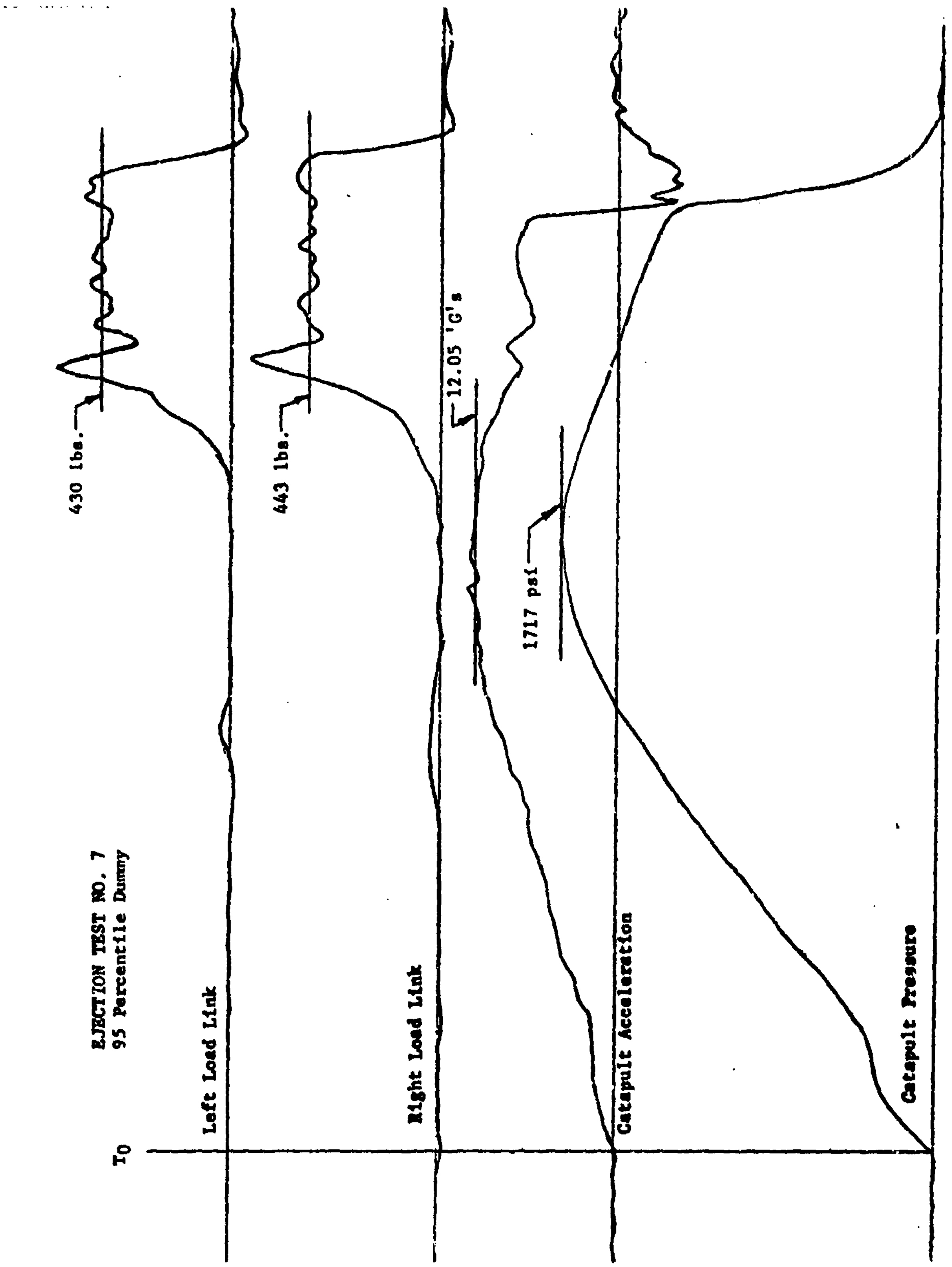

FIGURE 11 - Oscillograph Record - Test No. 7

Tests number 8 and 9 were also totally successful and were identical to test No. 7. The test records are shown in figures 12 and 13. Complete entrapment and tensioning through the locking snubber proved to be satisfactory.

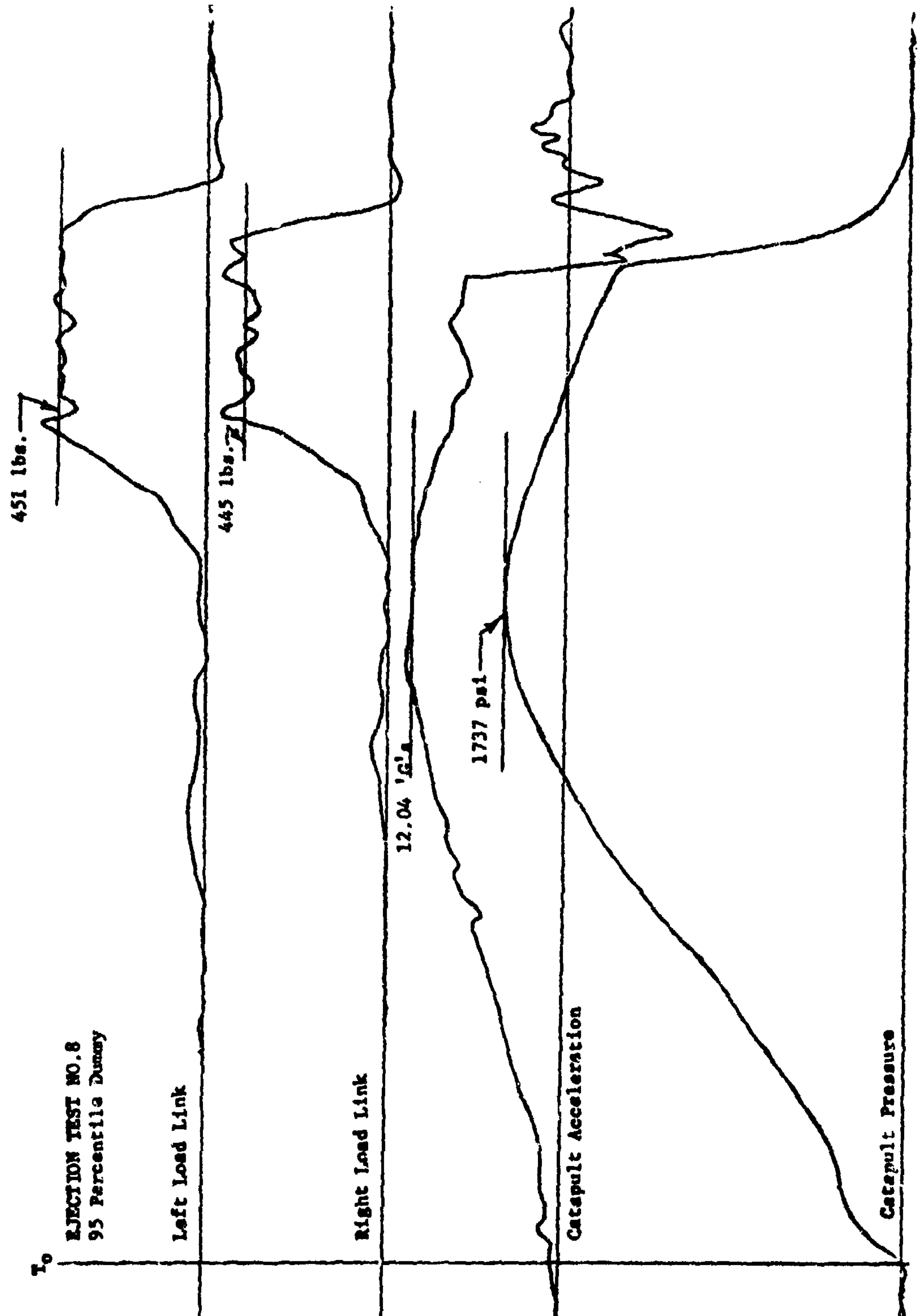

FIGURE 12 - Oscillograph Record - Test No. 8

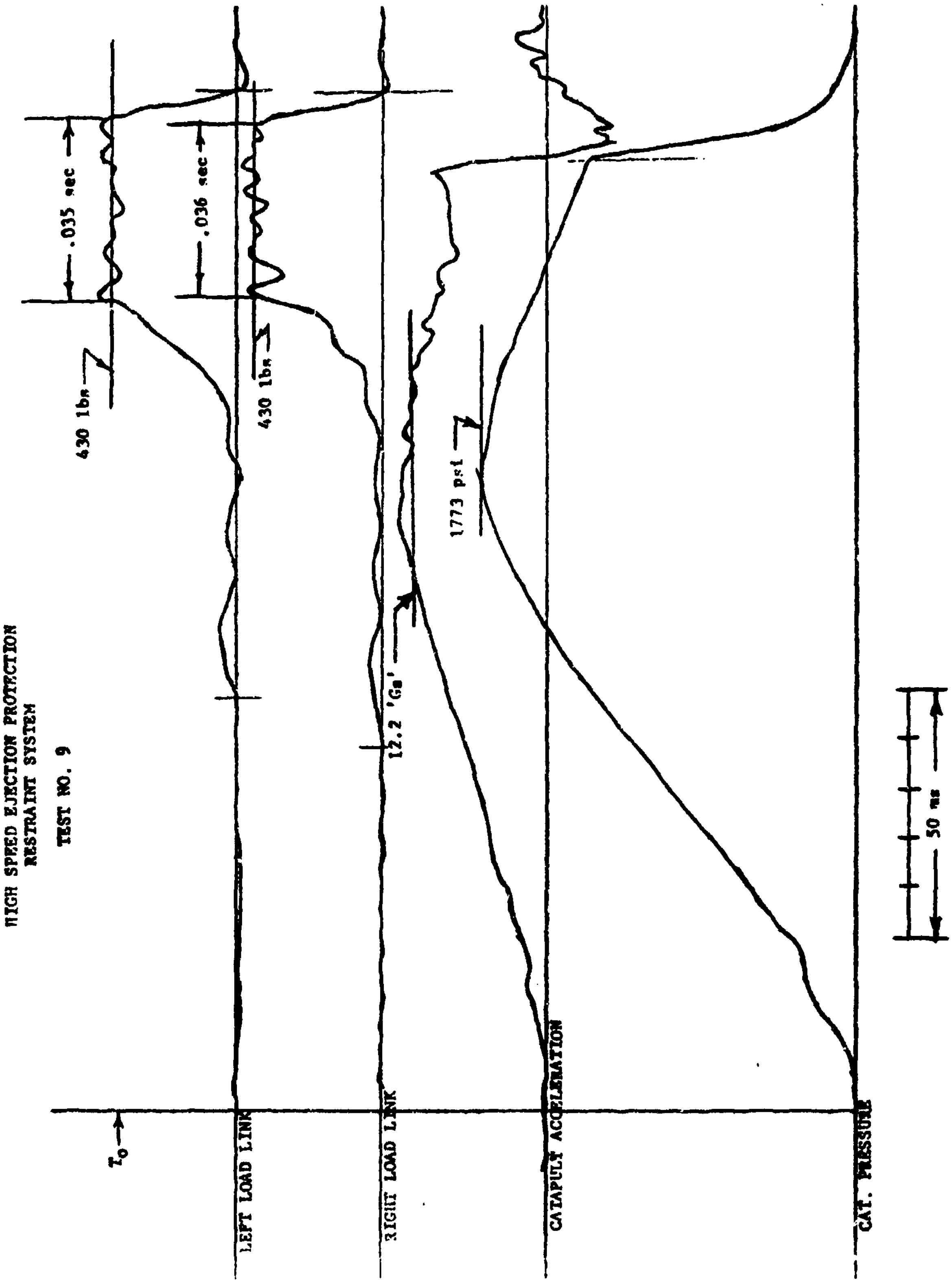

FIGURE 13 - Oscillograph Record - Test No. 9

Ejection Test Conclusions and Recommendations

1. Despite earlier problems with the snubbers and E/A webbing, all nine ejection tower tests resulted in complete leg entrapment as the seat moved up the rails showing excellent repeatability.

2. The prototype system successfully entrapped both 5th and 95th percentile dummy legs with no alterations or adjustments to the installed configuration.

3. The E/A webbing provided a constant retraction load for the tensioning phase when the last four rows of stitching sewn across the separation end are removed. It is recommended that this stitching, normal to the line of action to the strap, be permanently removed for this application. It is further recommended that a study be conducted to determine the trade off between the optimum E/A force necessary for positive retention and crewmember comfort.

4. The location of the arm nets were found to be satisfactorily located for the range of dummy sizes utilized during controlled test conditions, but still marginal. It is recommended that the arm retention nets be enlarged to ensure complete entrapment and retention for the full range of percentile population regardless of aircraft attitude or anticipated seat maneuvers during the ejection sequence.

5. The system configuration showed no indication of interference with other seat components nor did it hinder the crewmember in any way. There did not appear to be any added difficulties in seat maintenance requirements as a result of the installation of the limb retention system, as currently configured.

6. An area requiring further investigation and development is the function time and sequencing requirements. In addition to the time required for the deployment of the system via the inflatable bladders, motion of the seat up the rails is also required to complete the deployment of the leg entrapment straps. Additional motion of the seat up the rails is also required to completely cinch up the restraint straps via the E/A tear webbing lanyard which is attached to the floor beneath the seat.

A review of the photographic coverage and the oscillograph records revealed that strap tensioning was still occuring after catapult separation had occured. This condition should be investigated to determine its effects on escape system performance and the possibility of shortening the E/A lanyard without compromising the system's effectiveness. Although the legs are back and tight against the seat bucket, it is desirable to have the system sequencing fully completed prior to full exposure to the aerodynamic forces.

PHASE III - WINDBLAST TESTING

The windblast test program was conducted at Dayton T. Brown Co. to determine how effective the restraint system configuration was in restraining the limbs at various pitch and yaw attitudes at air speeds between 400 and 600 knots. For these tests, a 95th percentile dummy was used and was dressed in

only a flight suit, MA-2 integrated torso harness, boots, and helmet.

Due to the unavailability of a test-worthy prototype seat bucket, the Hi-'Q' restraint system was installed on an ESCAPAC type ejection seat for the windblast test series. Very little modification of either the restraint system or the seat was required to complete this installation, which reflects the adaptability of this restraint configuration to various seat systems.

The system was exposed to the following 9 windblast conditions.

1.	Head-On	477 Keas
2.	45^o Pitch Forward	420 Keas
3.	45^o Pitch Aft	420 Keas
4.	90^o Yaw Port	420 Keas
5.	45^o Yaw Port	425 Keas
6.	45^o Yaw Starboard	413 Keas
7.	90^o Yaw Starboard	425 Keas
8.	45^o Yaw Port	537 Keas
9.	Head-On	614 Keas

The restraint system was preset in the deployed condition as it would enter the windstream, with each strap required to be tensioned to approximately 400 lb. All the dummy's joints were loosened so that there was no frictional resistance and so that full range of motion of the limbs could easily be accomplished if they were not sufficiently restrained.

Test Description and Results

Head On

The set-up for this test is shown in figure 14. The seat was installed at a nominal 17 degree angle to conform to a typical installation position. The restraint system was pretensioned prior to each test. During this 477 knot exposure, the arms moved down to the seat sides (figure 15) but were adequately trapped by the arm nets. The legs were also adequately restrained. Following the test, it was discovered that the restraint lines were tensioned to only 200 lb. instead of the required 400 lb. This would explain the reason the arms moved down from the initial ejection position between the legs. However, the limbs were considered adequately restrained. An examination of the restraint system, dummy, and seat showed no evidence of damage nor any injury potential to the occupant.

FIGURE 14 - Windblast Test Set-Up - Head - On

FIGURE 15 - Post Test Condition - Head - On

Pitch Forward - 45 Degrees - 420 Knots

For this test, the seat was pitched forward 45 degrees from the vertical and was considered to be one of the more stringent tests (figure 16). The seat/dummy system was positioned only a few inches from the windblast nozzels. The open angle of the seat was fully subjected to the 420-knot windblast exposure. The restraint system was properly tensioned to 400 lbs.

FIGURE 16 - Windblast Test Set-Up - Pitch Forward 45 Degrees

Immediate examination of the system following the test showed that the dummy's limbs were perfectly restrained in the initial pre-test position (figure 17). A review of the high-speed film emphasized the excellent restraint provided by this system configuration during the exposure.

FIGURE 17 - Post Test Condition - Pitch Forward 45 Degrees

Pitch Aft - 45 Degrees - 420 Knots

For this test the seat was positioned 45 degrees aft of vertical (figure 18). The restraint system was again checked for proper tensioning. This position was subjected to a 420-knot windblast with the emphasis on the ability of the system configuration to hold the legs from coming off the seat pan. This test was very successful. Again, the post test examination as well as a review of the high-speed film showed excellent restraint. The arms were retained in the nets, and the legs were tightly restrained against the seat pan, front bucket, and side panels.

FIGURE 18 - Windblast Test Set-Up - Pitch Aft - 45 Degrees

Yaw TEST - 45 Degrees - Starboard and Port

For this test, the seat was replaced in the original 17 degrees aft of vertical and then first yawed 45 degrees to the starboard side (figure 19). The system was then subjected to a 420 knot windblast exposure. Again, the limbs were satisfactorily restrained.

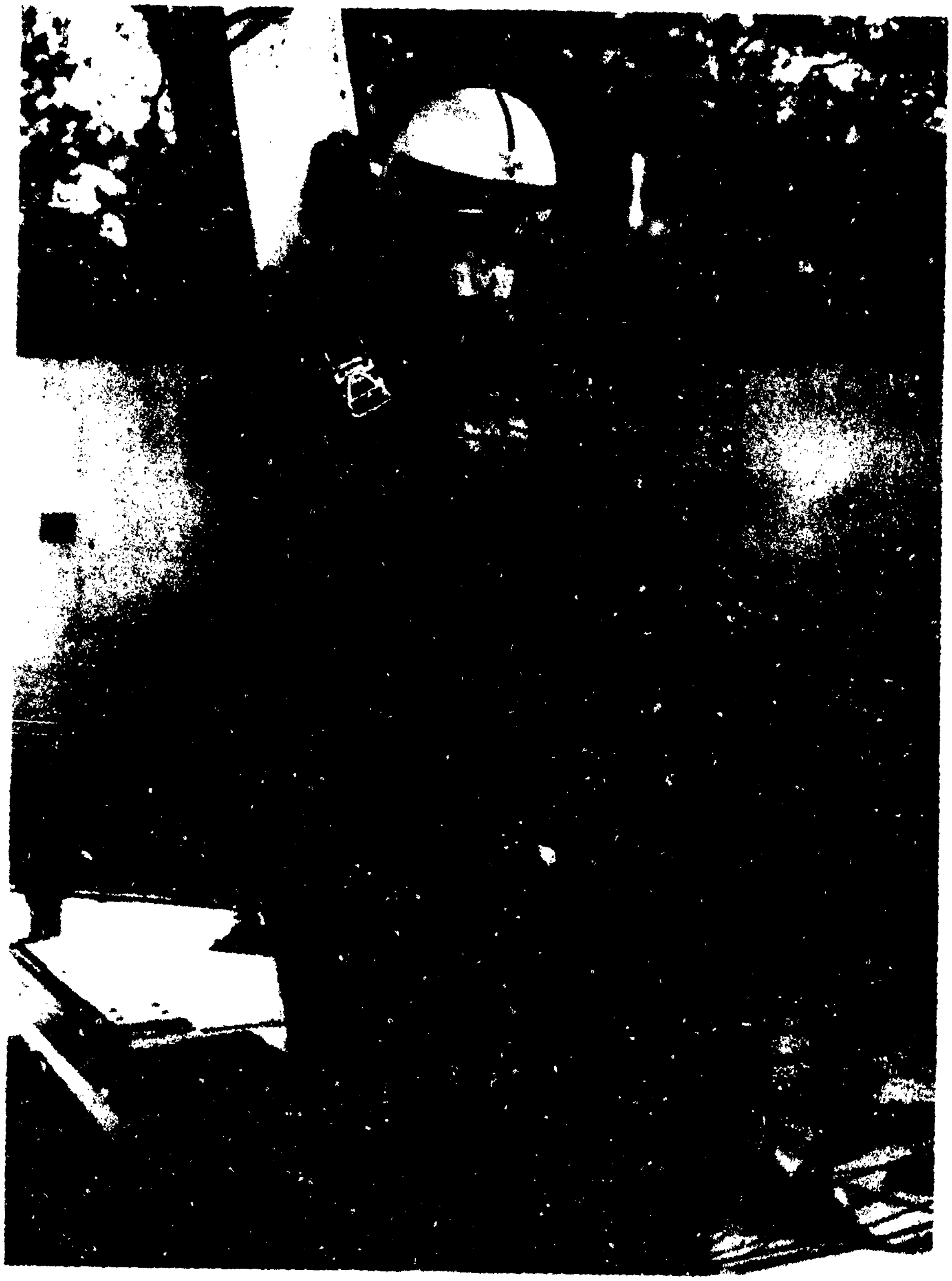

FIGURE 19 - Windblast Test Set-Up - Yaw 45 Degrees Starboard

The only motion observed was the slight movement of the dummy's legs in the direction of the windblast, as would be expected, but still adequately restrained (figure 20). The test was repeated on the port side with similar successful results.

FIGURE 20 - Post Test Condition - Yaw 45 Degrees Starboard

Yaw Test 90 Degrees - Port and Starboard - 420K

Following the successful 45-degree yaw test, the seat was rotated to a full 90-degree yaw position relative to the air nozzles (figure 21).

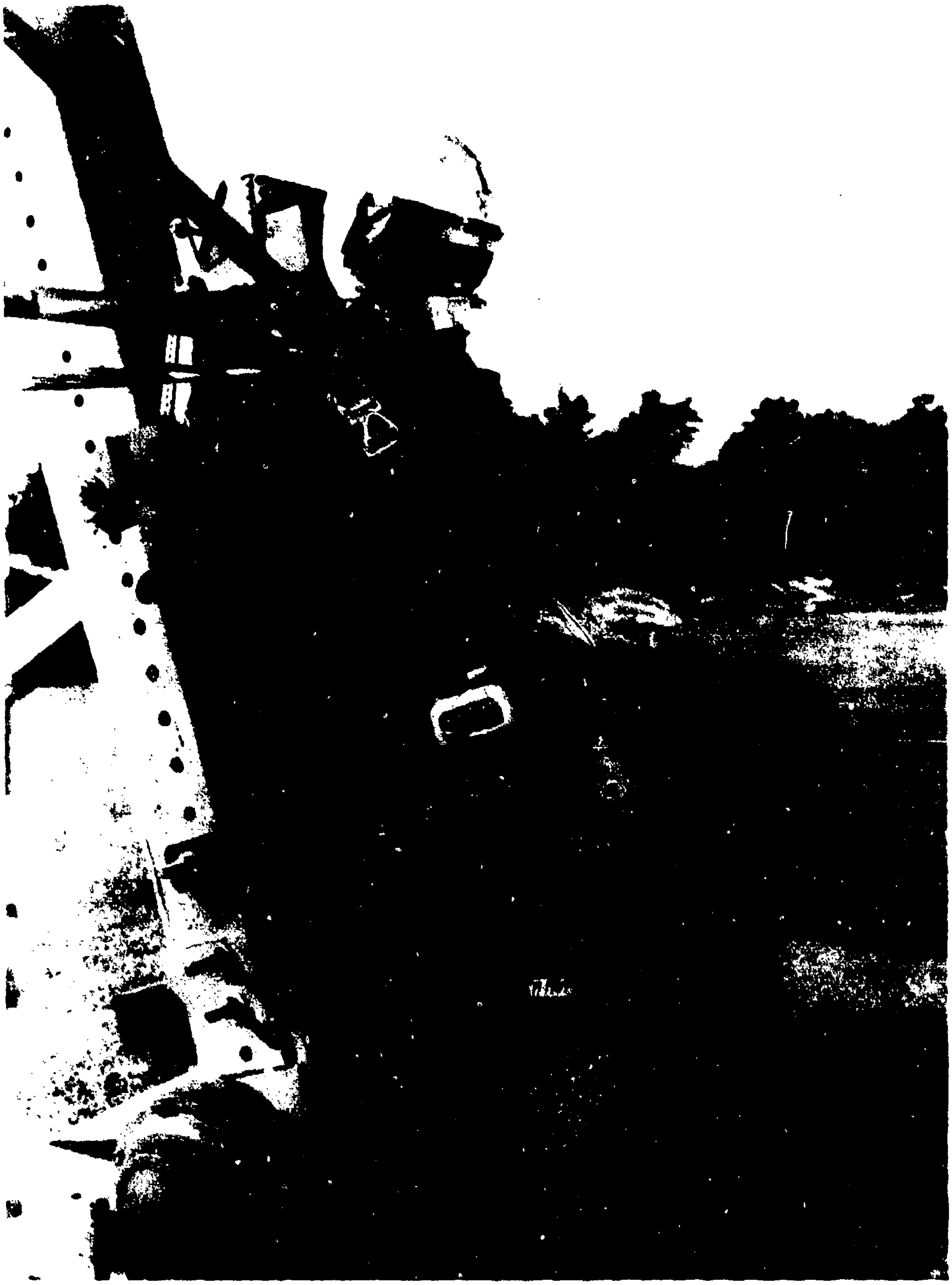

FIGURE 21 - Windblast Test Set-Up - Yaw 90 Detrees Port

After resetting the tension in the restraint lines, the system was subjected to a 420-knot test on the port side. The results of this exposure were very successful. The limbs were completely retained. The only observable motion was slight sideways motion of one leg and some side motion of the right arm in the direction of the windblast (figure 22). The same test was conducted on the starboard and exhibited the same excellent degree of restraint. The system evidenced no damage to either the dummy or the restraint system.

FIGURE 22 - Post Test Condition - Yaw 90 Degrees Port

45 Degree Yaw - 537 Knots

Upon successful completion of the 400-knot level tests, it was decided to retest two previous conditions at higher air speeds.

The seat was positioned again at 45 degrees yaw to the port side (figure 23).

FIGURE 23 - Windblast Test Set-Up - 45 Degree Yaw - 537 Knots

After resetting the strap tension loads in the leg lines, the system was subjected to a 550-knot windblast exposure. The system was examined immediately after the test and the dummy's limbs were found to be perfectly restrained and secured in the ejection position. Subsequent analysis of the high-speed film coverage confirmed the adequacy of the restraint configuration to protect and secure the limbs for this condition. As before, the only motion in the dummy was some slight sideways motion of one leg in the direction of the windblast (figure 24).

FIGURE 24 - Post Test Condition - 45 Degree Yaw - 537 Knots

Head - On - 605 Knots

The final test of the windblast series was a 600K level exposure. The seat was positioned at the nominal 17-degree seat back angle and straight ahead to the windblast direction (figure 25). As before, the restraint line tension loads were checked prior to the test. The right hand line was easily tensioned to the 400-lb. level and locked via the snubber. The left hand restraint line was also tensioned to the 400-lb. level, but it was not readily locked in place via the snubber when the applied tensioning load was released. The snubber was only able to be locked after some slippage of line as the load was being released. After several unsuccessful attempts to lock the snubber at the 400-lb. load level, it was necessary to allow the snubber to lock at a lower level, (which was not observable) but was estimated at about 300 lbs.

FIGURE 25 - Windblast Test Set-Up - Head - On 605 Knots

At peak exposure, the dummy's left arm translated down approximately parallel to the seat back (figure 26), but was still entrapped by the arm net. The arm was prevented from flailing. The obvious reason for this arm motion was due to the extra slack allowed in the restraint line because of the problem with locking the snubber at the 400-lb. load level.

FIGURE 26 - Post Test Condition 605 Knots Port Side

The right arm was perfectly retained in its original position (figure 27). The test however, was still considered very successful.

FIGURE 27 - Post Test Condition - 605 Knots Starboard Side

It should be noted that with slight modification to this feasibility prototype, it is possible to assure total arm retention and protection against flailing, despite slack in the system and hence, eliminate large variations in tension loads, as a critical element in system reliability and performance. The results of the test and evaluation of the windblast testing phase were considered highly successful and extremely encouraging. The information obtained from the overall test and evaluation study will provide the basis for the development of an advance prototype model.

FUTURE DEVELOPMENT AND TEST PLANS

Current plans are to continue to the advanced development stage of hardware fabrication in order to conduct additional testing of a refined prototype which will provide better performance, increased reliability, simplify packaging techniques, and further demonstrate the suitability of the technical approach. This advanced development model will be configured for and installed on the latest version MPES seat and will be suitable for testing at the 400- to 600-knot speed range. In addition, a preliminary reliability and maintainability analysis of the advanced development model will be conducted.

Some of the more critical elements to be given more consideration and evaluation for the advanced prototype are:

1. To ensure that the system design is optimized to accommodate the 3rd through the 98th percentile population.

2. To ensure that the arm and leg retraction or entrapment would be achieved regardless of aircraft attitude, and to ensure 'G' environment or crewmember position at the time of ejection, especially in the case of a command ejection.

3. Ensure that the limbs are fully entrapped and restraint lines locked prior to leaving the aircraft or immediately prior to limb exposure to windblast.

4. To ensure that the limb entrapment system design is compatible with the sequencing requirements of the ballistic inertia reel which retracts and restrains the crewmember's upper torso.

5. Eliminate or optimize to the maximum extent possible the need for critical sequencing (times) between the deployment and cinch-up phases of system operation.

6. Determination of optimum strap tensioning loads required and ensure that they will not cause any injury or severe discomfort to the crewman. Also, to ensure that successful operation of the system is not to be jeopardized by small variations in strap tension.

Future Testing

Upon receipt of an advanced development model, additional testing will be conducted. In addition to dummy testing on the ejection tower and the

windblast facility, the following will also be investigated:

1. Live Cockpit Ejection Simulation - Representative 3rd and 98th percentile volunteers will be used to conduct a series of cockpit ejection simulations to obtain a subjective evaluation of the protection restraint system. These tests will be conducted at the Naval Air Test Center, Patuxent River, MD, on their ejection simulator. This device will lift the seat out of a cockpit at a low onset rate and peak 'G' level, allowing the restraint system to retract and tension all the straps following a full-up in-cockpit deployment. These tests will provide full system check out and allow for a subjective evaluation to assess the degree of restraint provided and any associated discomfort experienced during system deployment while confined or during the actual egress of the seat from the simulated cockpit area.

2. High Speed Sled Tests - During the normal development process of the MPES ejection seat system, high speed nonejection sled tests are being considered to evaluate the seat structure, to obtain aerodynamic data, and to evaluate other seat components. A predeployed high 'Q' limb restraint system will also be installed and evaluated up to 600 knots. These exposures will be in addition to the windblast facility tests and will provide a more realistic aerodynamic environment in which to evaluate the system performance.

3. Static Evaluation

a. A test agenda will be prepared to evaluate the effectiveness of the system to entrap the limbs of an out-of-position crewmember as might be the case during a command ejection.

b. During this static evaluation, the sequential operation of the inertia reel and the limb retention system will also be examined to ensure compatibility.

c. Seat-man separation studies will be conducted to determine if the existing releases are adequate and will not result in any snags, hangups, or in any way impede the separation process.

TABLE I - EJECTION TOWER TEST DATA

TEST NO.	SEAT	DUMMY WT. (lb)	TOTAL EJECTED WT. (lb)	CATAPULT "G's"	ONSET RATE (G's/sec)	TOWER HT. (ft)
1	MPES	160	436	10.9	126	32
2	MPES	160	436	12.4	137	37
3	MPES	160	486	12.2	151	36
4	MPES	160	486	(NO RECORD)		37
5	MPES	160	486	12.0	148	37
6	MPES	160	486	12.3	147	38
7	MPES	233	559	12.1	147	38
8	MPES	233	559	12.0	127	39
9	MPES	233	559	12.2	137	40

TABLE II - WINDBLAST TEST PROGRAM SUMMARY

TEST NO.	FIXED ATTITUDE POSITION	VELOCITY KEAS	DUMMY (%)
1	HEAD-ON	477	95
2	45° PITCH FWD.	420	95
3	45° PITCH AFT	420	95
4	90° YAW PORT	420	95
5	45° YAW PORT	425	95
6	45° YAW STBD.	413	95
7	90° YAW STBD.	425	95
8	45° YAW PORT	537	95
9	HEAD-ON	614	95

D I S T R I B U T I O N   L I S T

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